Better Buildings®
U.S. DEPARTMENT OF ENERGY

JUNE 8–11

2020 SUMMIT

A Virtual Leadership Symposium

Learn more: betterbuildingssolutioncenter.energy.gov/summit

U.S. DEPARTMENT OF ENERGY

Data Center Sector Meet-Up

June 8th

1:00 – 2:30pm ET

Webinar Housekeeping

- Please note, today's session will be recorded and archived on the Better Buildings Solution Center. We will follow up when today's recording and slides are made available.

- If you experience any audio or visual issues anytime throughout today's session, please send a message in your "chat" window located on the bottom of your zoom panel.

- As an attendee please turn your webcam feature off. This will help minimize distractions and draw attention towards the panelists.

Rachel Shepherd

U.S. Department of Energy
Federal Energy Management Program (FEMP)
Data Center Accelerator - Lead

Agenda

1) Welcome and Introduction

2) Overview of Data Center Accelerator Toolkit

3) Partner Presentations

    - **Iron Mountain** – *Jim Henry*
    - **Sabey Data Centers** – *John Sasser*
    - **Oak Ridge National Laboratory** – *David Grant*
    - **Lawrence Berkeley National Laboratory** – *Steve Greenberg*

4) Questions and Answer Session

5) Wrap-up

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Select the session – Data Centers Meet-up

Today’s Speakers

Dale Sartor
Lawrence Berkeley National Laboratory

Steve Greenberg
Lawrence Berkeley National Laboratory

Ian Hoffman
Lawrence Berkeley National Laboratory

Hannah Stratton
Lawrence Berkeley National Laboratory

David Grant
Oak Ridge National Laboratory

Jim Henry
Iron Mountain

John Sasser
Sabey Data Centers

Poll #1

On a scale of 1 to 5, how familiar are you with data centers?

(5 = very familiar, 3 = somewhat familiar, 1= new to the sector and building type)

Poll #2

What sector does your organization represent?

Better Building Partners Are

FORTUNE 100

30 of the Fortune 100 Companies

30% of all Commercial Building space

28 state governments

93 local governments

8 National Laboratories

12 of the Top 25 U.S. employers

12% of the U.S. Manufacturing Energy Footprint

Better Buildings Data Center Challenge Partners

IRON MOUNTAIN

SABEY Data Centers

DIGITAL REALTY

intuit®

ebay

Schneider Electric

CenturyLink™

MICHIGAN STATE UNIVERSITY

intel

Better Buildings Data Center Accelerator Partners

Thank you for your participation!

Argonne National Laboratory	Defense Health Agency (DHA)	Environmental Molecular Sciences Laboratory
Georgia Institute of Technology	Indiana University	Lawrence Berkeley National Lab
Lawrence Livermore National Laboratory	Los Alamos National Laboratory	NASA Armstrong Flight Research Center
National Energy Research Scientific Computing Center	National Renewable Energy Laboratory	Oak Ridge National Laboratory
Stanford University	State of Michigan	U.S. Department of Defense - Defense Information Systems Agency
U.S. Social Security Administration	U.S. Department of Veterans Affairs	U.S. Environmental Protection Agency
Waste Management	University of Colorado	

Data Center Accelerator Results

Data Center Accelerator partners worked to reduce the infrastructure energy intensity of one or more data centers by 25% over 5 years. So far, Accelerator partners have achieved:

- An average **36%** improvement in their data center's infrastructure energy intensity surpassing the Accelerator's original goal.
- **$3.9 million** in annual cost savings

Ongoing Data Center Support

Both targeted data center efforts are concluding, however, we are still providing support in the following ways:

1. Join the Better Buildings Challenge!
   - Commercial Sector, Higher-education, Industrial

2. If you are a federal agency, request assistance from DOE's Federal Energy Management Program for technical and procurement support

3. Reach out to betterbuildingschallenge@ee.doe.gov for question and technical support

Resources:

- Visit the Better Buildings Solution Center
- Visit LBNL's Center of Expertise for Energy Efficiency in Data Centers

Poll #3

What type of data center do you work in?

Poll #4

What role do you have at your data center? (e.g., are you an owner, facility manager, or a customer?)

Data Center Accelerator - Toolkit Overview

Hannah Stratton
Program Manager
Lawrence Berkeley National Laboratory

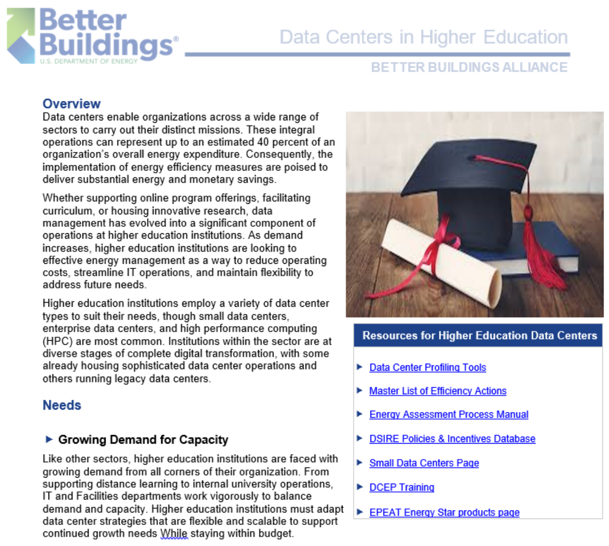
Ian Hoffman
Senior Scientific Engineer
Lawrence Berkeley National Laboratory

Data Center Energy Efficiency can Present a Significant Savings Opportunity

- Data Centers support critical operations in a wide range of sectors.
- Data centers can represent a significant portion of an organization's overall energy expenditure.
- Data Centers can be **10 to 50 times more energy intensive** than other typical building floor space.
- Energy efficiency measures are poised to deliver substantial energy and monetary savings.

Energy Efficiency Opportunities & Challenges Vary

- Across and within each sector, different factors influence the needs, barriers, and opportunities relative to implementing energy efficiency improvements:
  - Industry/sector trends
  - Data center type
  - Organizational structure & dynamic
  - Funding availability for improvements
  - Regulatory requirements (if applicable)
  - Current state of the data center
- Better Buildings Toolkit Series Sector Sheets provide more information and resources for implementing EE measures by sector



Better Buildings U.S. DEPARTMENT OF ENERGY

Data Centers in Higher Education

BETTER BUILDINGS ALLIANCE

Overview

Data centers enable organizations across a wide range of sectors to carry out their distinct missions. These integral operations can represent up to an estimated 40 percent of an organization's overall energy expenditure. Consequently, the implementation of energy efficiency measures are poised to deliver substantial energy and monetary savings.

Whether supporting online program offerings, facilitating curriculum, or housing innovative research, data management has evolved into a significant component of operations at higher education institutions. As demand increases, higher education institutions are looking to effective energy management as a way to reduce operating costs, streamline IT operations, and maintain flexibility to address future needs.

Higher education institutions employ a variety of data center types to suit their needs, though small data centers, enterprise data centers, and high performance computing (HPC) are most common. Institutions within the sector are at diverse stages of complete digital transformation, with some already housing sophisticated data center operations and others running legacy data centers.

Needs

Growing Demand for Capacity

Like other sectors, higher education institutions are faced with growing demand from all corners of their organization. From supporting distance learning to internal university operations, IT and Facilities departments work vigorously to balance demand and capacity. Higher education institutions must adapt data center strategies that are flexible and scalable to support continued growth needs While staying within budget.

Resources for Higher Education Data Centers

- Data Center Profiling Tools
- Master List of Efficiency Actions
- Energy Assessment Process Manual
- DSIRE Policies & Incentives Database
- Small Data Centers Page
- DCEP Training
- EPEAT Energy Star products page

Common Data Center Needs Across Sectors

- **Heightened Demand for Capacity**
  - Trend towards digital transformation has demanded the quick scaling up of IT capacity.
  - Facilities & IT working together to close the gap between demand and capacity.
- **Reduce the Management Burden**
  - Lack of standardization can result in inefficiencies and a higher management burden for staff.
  - Operational efficiency gains must be present to ensure expansion of capacity is manageable.
- **Risk Management & Reliability**
  - Data centers are important mission critical and play an increasingly integral role in organizations.
  - The need to maintain continuity of important services means that reliability is a top-of-mind concern.
- **Security**
  - Data breaches are costly! (both monetarily, and from a reputation standpoint).
- **Meeting Requirements**
  - Federal data centers subject to Administration's priorities and policies- e.g. DCOI.

Common Data Center Types by Sector

- Different data center types are found within each sector, but some are more commonly found than others.
- Organizations face different barriers to, and have different opportunities for, energy efficiency improvements depending on data center type.

Sector	Small Data Centers	Enterprise	Co-Los	Hyperscale	High Performance Computing (HPC)
State & Local Government	X	X			
Federal Government	X	X			X
Higher Education	X	X			X
Commercial	X	X	X	X	
Industrial	X	X	X		X

Data Center Efficiency: One Size Doesn't Fit All

Key Determinants for Efficiency Opportunities and Challenges:

- Scale – physical and economic
- Mission – criticality
- Ownership and Management – IT vs. Facilities vs. Finance
- Performance Requirements – availability, redundancy
- Location – integration with other facilities, climate
- Age and Upkeep

Data Center Types

Small DCs Under 5,000 square feet of computer floor space or embedded in an office. More than half of all servers in the data center industry.

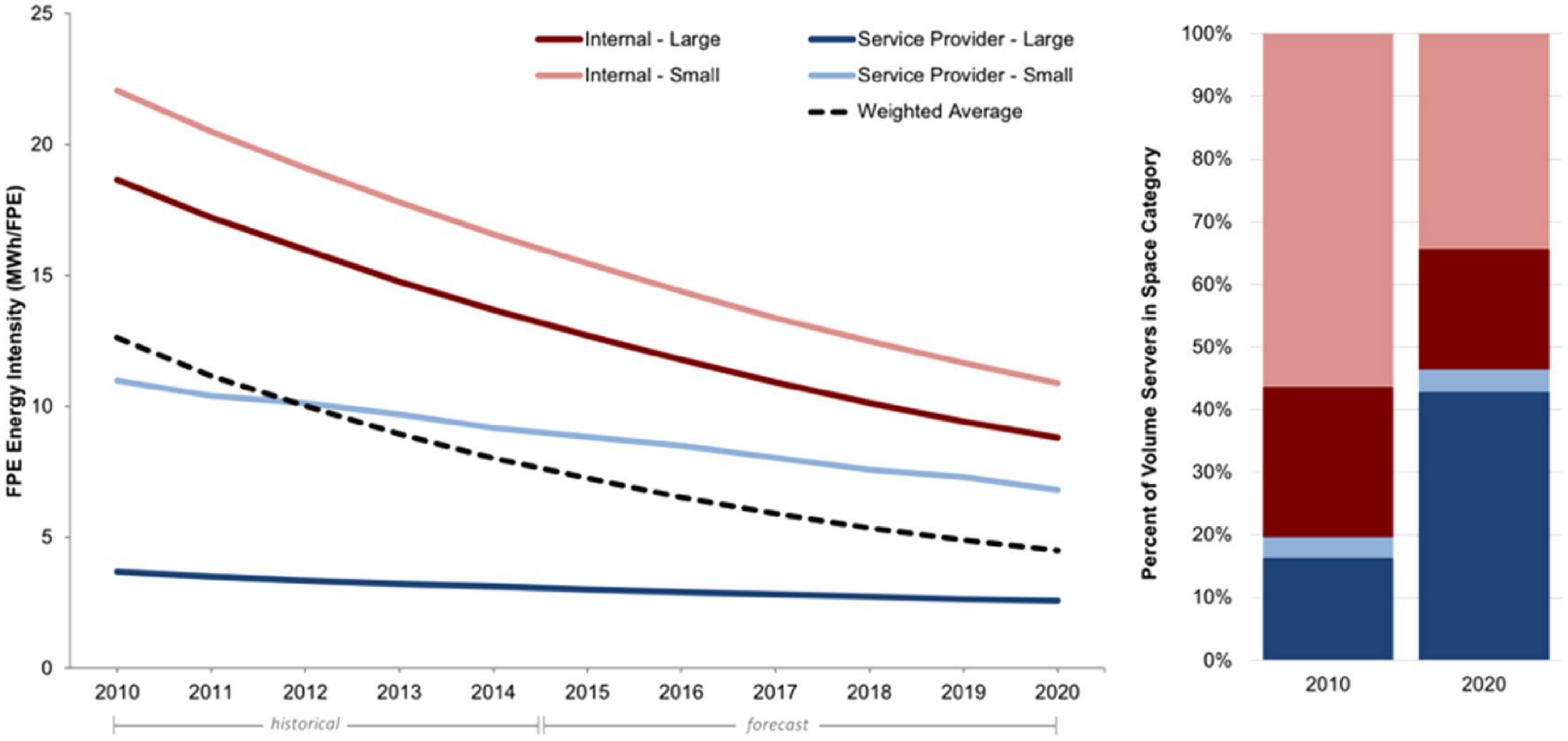
Enterprise Owned and operated by a single company and core to the firm's operational integrity. Often sizable though not as large as hyperscale. High availability requirements.

Colocation Owner leases space, power and cooling to hundreds, even thousands of customers, each with varying IT hardware and needs.

Hyperscale Owned/operated by large tech, cloud and telecom providers. Massive; very high energy/water requirements. Largest efficiency opportunity by some analyses. Medium availability requirements.

High-Performance Race cars of DCs with high server utilization rates and high-power requirements but typically low availability requirements. Universities and research centers, but increasingly oil/gas, finance/investment, IT design, etc.

Data Center Energy Use by Type



Source: Arman Shehabi et al. 2018 Environ. Res. Lett. 13 124030 doi:10.1088/1748-9326/aaec9c

Small Data Centers

Headwinds

- Lean staff, capital
- Distributed, disconnected
- Embedded with other uses

Opportunities

- Cloud, consolidation, virtualization
- Air management
- Temperature control

Enterprise

Headwinds

- Often high availability requirements
- Diverse stakeholder set, divergent interests
- Leadership focus

Opportunities

- Cloud, virtualization
- IT upgrades, load management
- Air management, temperature
- Modular, high-efficiency UPSs with bypass or “ecomode” capability

Colocation Facilities

Headwinds	Opportunities
Broad stakeholder set, divergent interests	Common requirements for cooling, power quality
Diverse IT installations and refresh rates	Common infrastructure, e.g., for air management
Leadership focus	Selling efficiency as cost control

Hyperscale

Headwinds

- High and rising loads
- Scale – forced phasing
- Repeatability/clonability

Opportunities

- Virtualization
- Network redundancy
- Staggered IT upgrades, load management
- Liquid cooling
- Air management, temperature adjustment
- High voltage, DC, storage

High-Performance Computing Centers

Headwinds

- High and rising loads
- Already high utilization rates
- Diverse stakeholders

Opportunities

- IT upgrades, load management
- Liquid cooling, novel chiller/tower designs
- Air management, temperature
- Economizing

Partner Case Studies

Jim Henry

Senior Governance, Risk & Compliance Analyst

Iron Mountain Data Centers

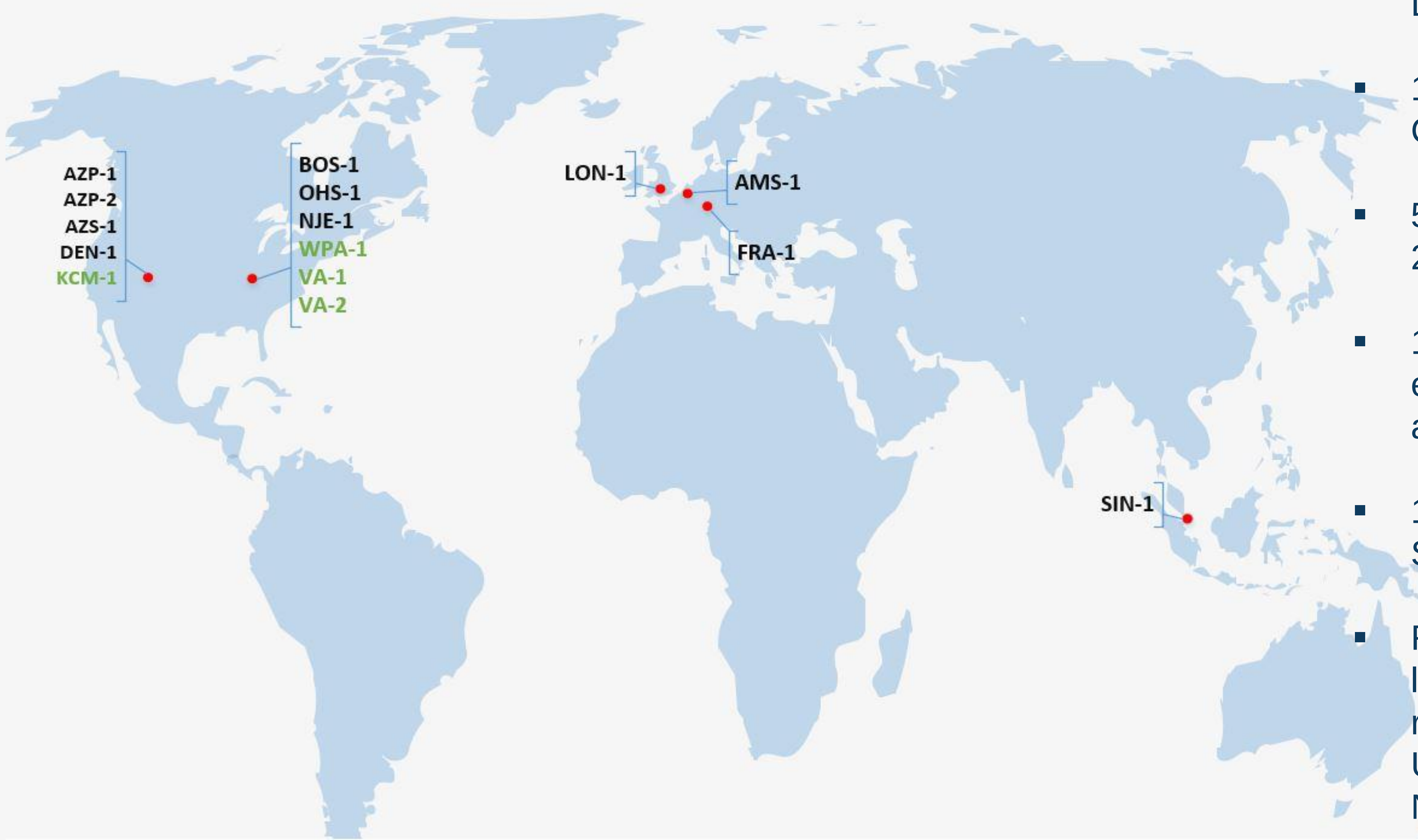
U.S. DEPARTMENT OF ENERGY

Iron Mountain Data Centers

Jim Henry | Senior Governance, Risk & Compliance Analyst

IRON MOUNTAIN®

Current Footprint



- 15 Data Center Locations
- 1,300+ Colocation Customers
- 569,223 MWh used in 2019
- 15 current energy efficiency projects across all locations
- 100% Renewable Sourced Electricity
- Recently installed largest data center rooftop solar system in US (7.2 MW project in NJE)

Our Energy Management Story…

- **2016:** Iron Mountain Data Centers began in the Better Buildings Challenge with WPA-1 and KCM-1 in scope. An initial goal was set to improve energy efficiency, and ultimately reduce non-IT energy intensity by **25%** over a 10-year period.

- **2017:** Based on the goals that were set in the Better Buildings Challenge, and in order to align with greater goals and vision of the organization, IMDC prepared the portfolio (then, just 3 sites) for ISO 50001 Energy Management System certification. The **entire portfolio** was certified in late 2017.

- **2018:** This year brought great expansion with the acquisition of FORTRUST Data Centers in Denver, CO. The acquisition of two former privately owned data centers in Singapore, and the UK, and lastly, the acquisition of 4 sites from IO Data Centers. Later in 2018, IMDC successfully brought all acquired sites into the scope of the ISO 50001 system, being the **first data center company to certify an entire enterprise system in ISO 50001**.

- **2019:** Riding on the successes of programs and projects associated with ISO 50001, IMDC became a DOE Better Buildings Goal Achiever after submitting 2018 data, shattering the original goal **7 years ahead of target**. Additionally, IMDC rolled out *Green Power Pass*, **an industry first**, data center renewable energy solution that gives customers the ability to include the power they consume at any Iron Mountain data center as green power in their CDP, RE100, GRI, or other sustainability reporting.

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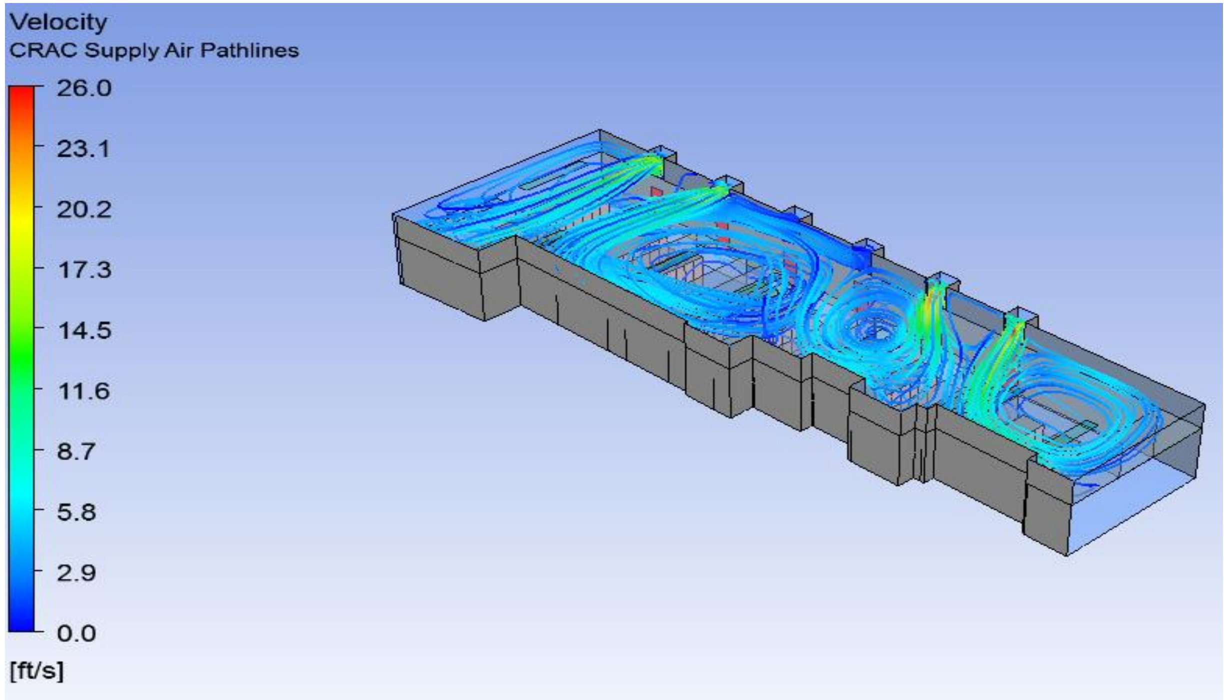
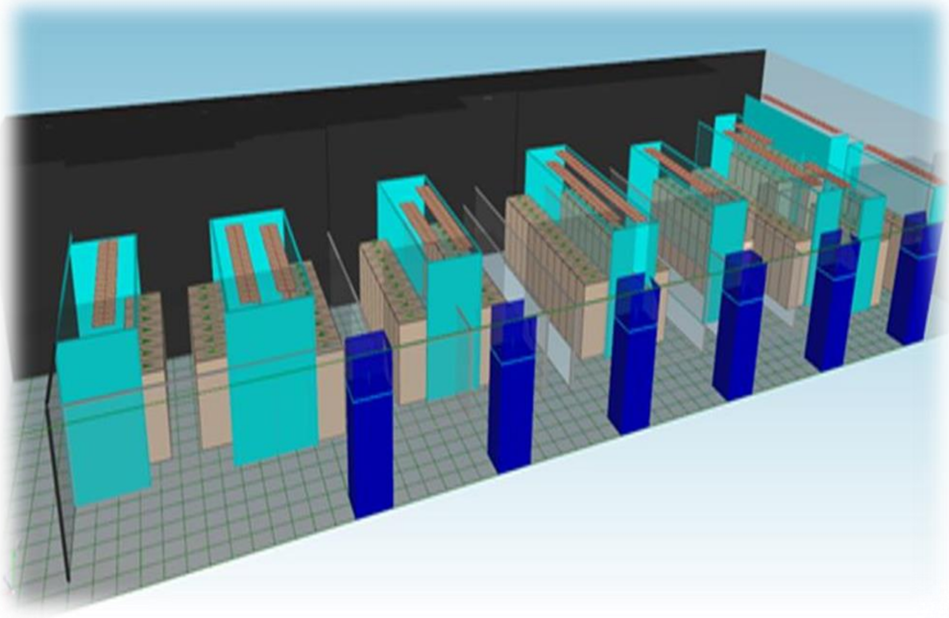
Projects and Advancements

Our underground data center, WPA-1, utilizes a unique geothermal cooling solution for part of the colocation space; an underground lake! This allows for recirculation of water naturally occurring in a secluded aquafer tucked in a part of the limestone mine where the data center is located. The 56 degree water is a part of the natural water table in Pennsylvania, and provides a great deal of efficiency when cooling data halls SC6-13.

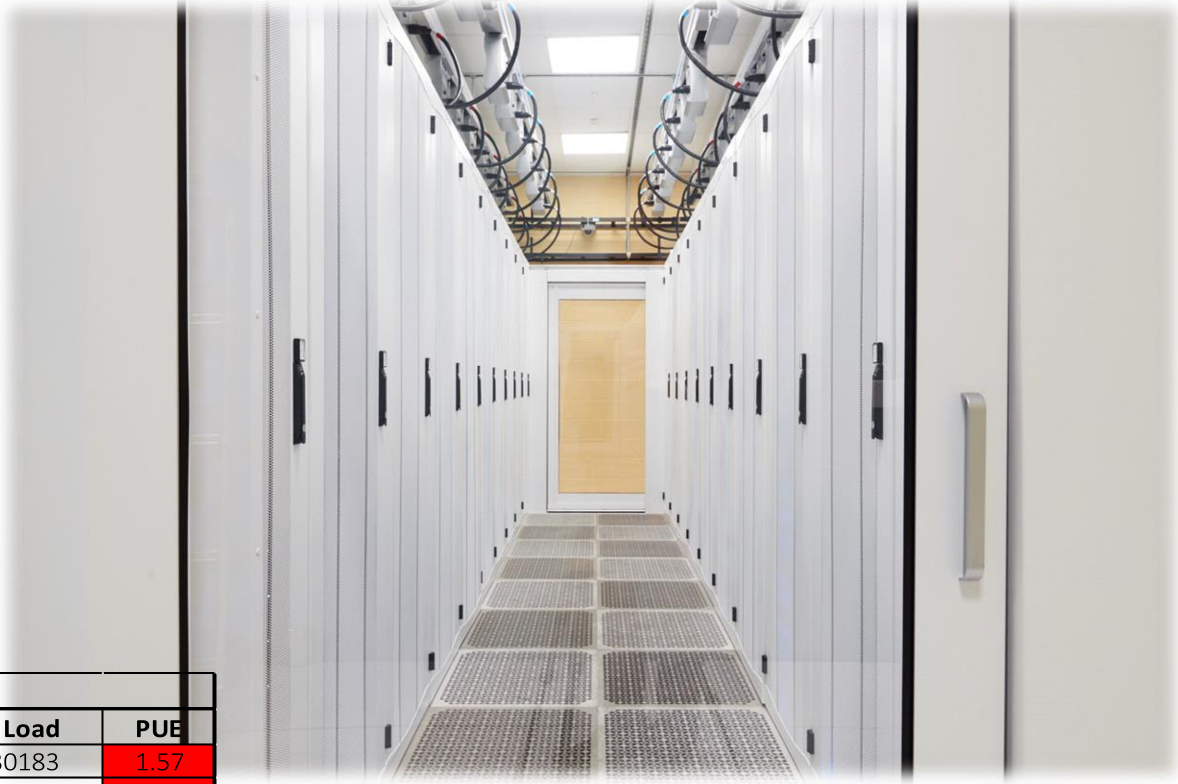
Projects and Advancements

In 2018 and early 2019, a large containment project was kicked off in our WPA-1 data center to install hot/cold aisle containment in data hall SC10. After an initial containment and airflow study, aggressive steps were taken in order to separate cold/hot aisles and improve efficiency. This project resulted in a **10.19%** reduction in PUE.





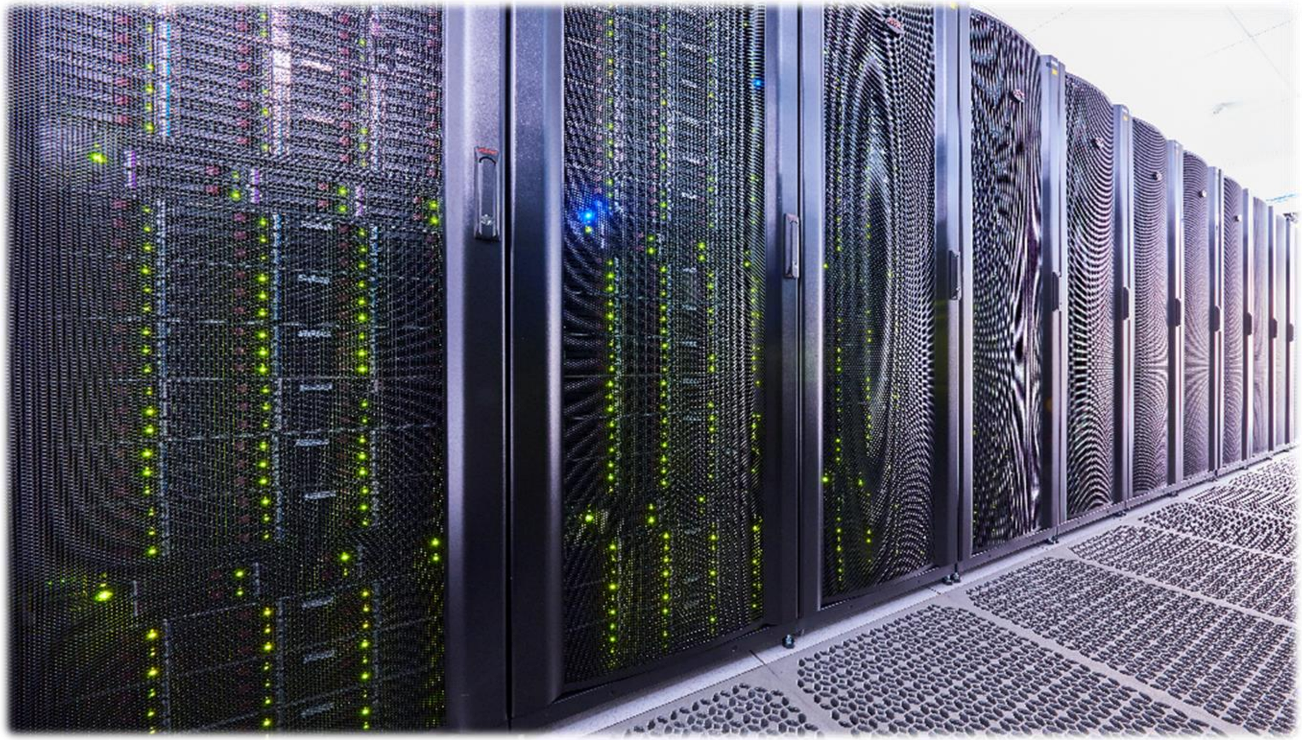
Projects and Advancements



NAT1.SC10			
Date	Facility Load	IT Load	PUE
1/28/18	203952	130183	1.57
2/28/18	197477	128395	1.54
3/28/18	171326	114957	1.49
4/28/18	195645	130818	1.50
5/28/18	190986	128383	1.49
6/28/18	198399	135421	1.47
7/28/18	195082	130372	1.50
8/28/18	202909	136871	1.48
9/28/18	179294	123093	1.46
10/28/18	180475	124712	1.45
11/28/18	188492	132333	1.42
12/28/18	167427	119060	1.41

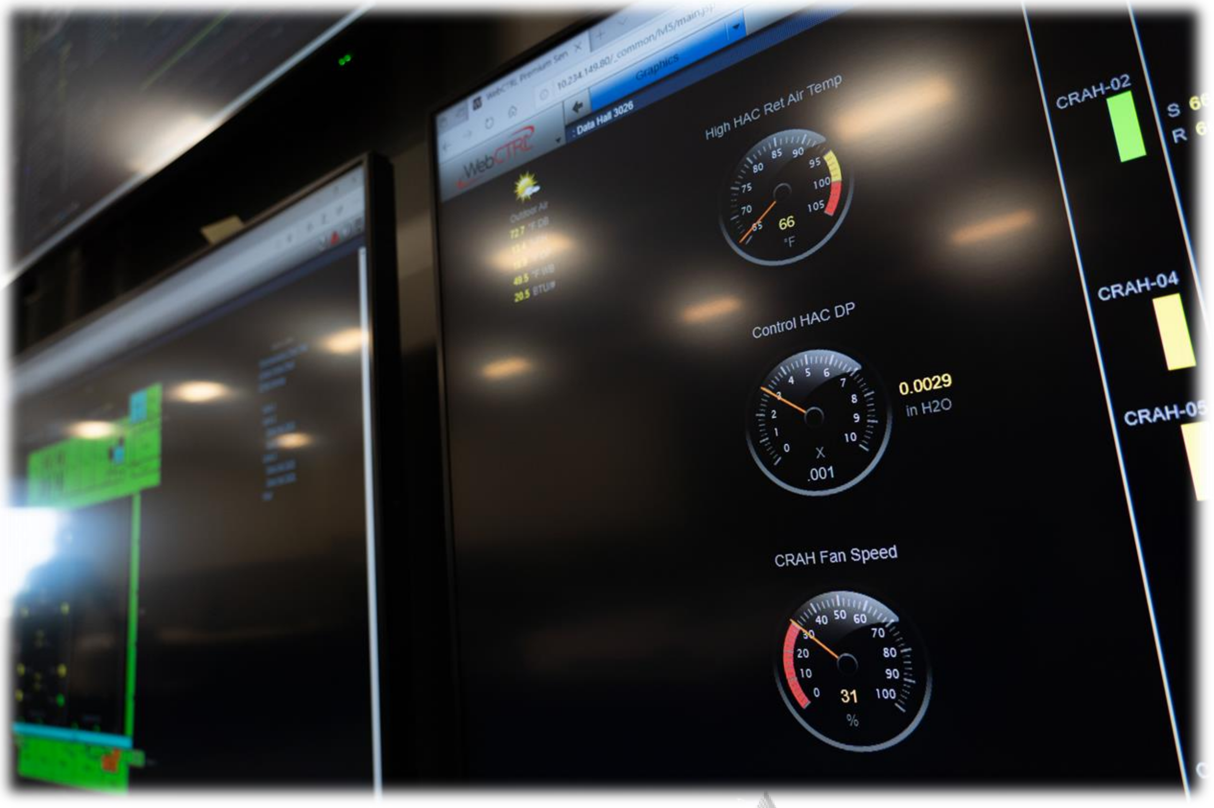
Projects and Advancements

Over the course of the last 2 years, another one of our underground data centers, KCM-1, has been installing containment across the data center colocation space in order to drive PUE numbers down. This, along with tuning fan speeds on the BMS have resulted in a great increase in efficiency, ultimately leading to a reduction in PUE from 1.83 to **1.68**

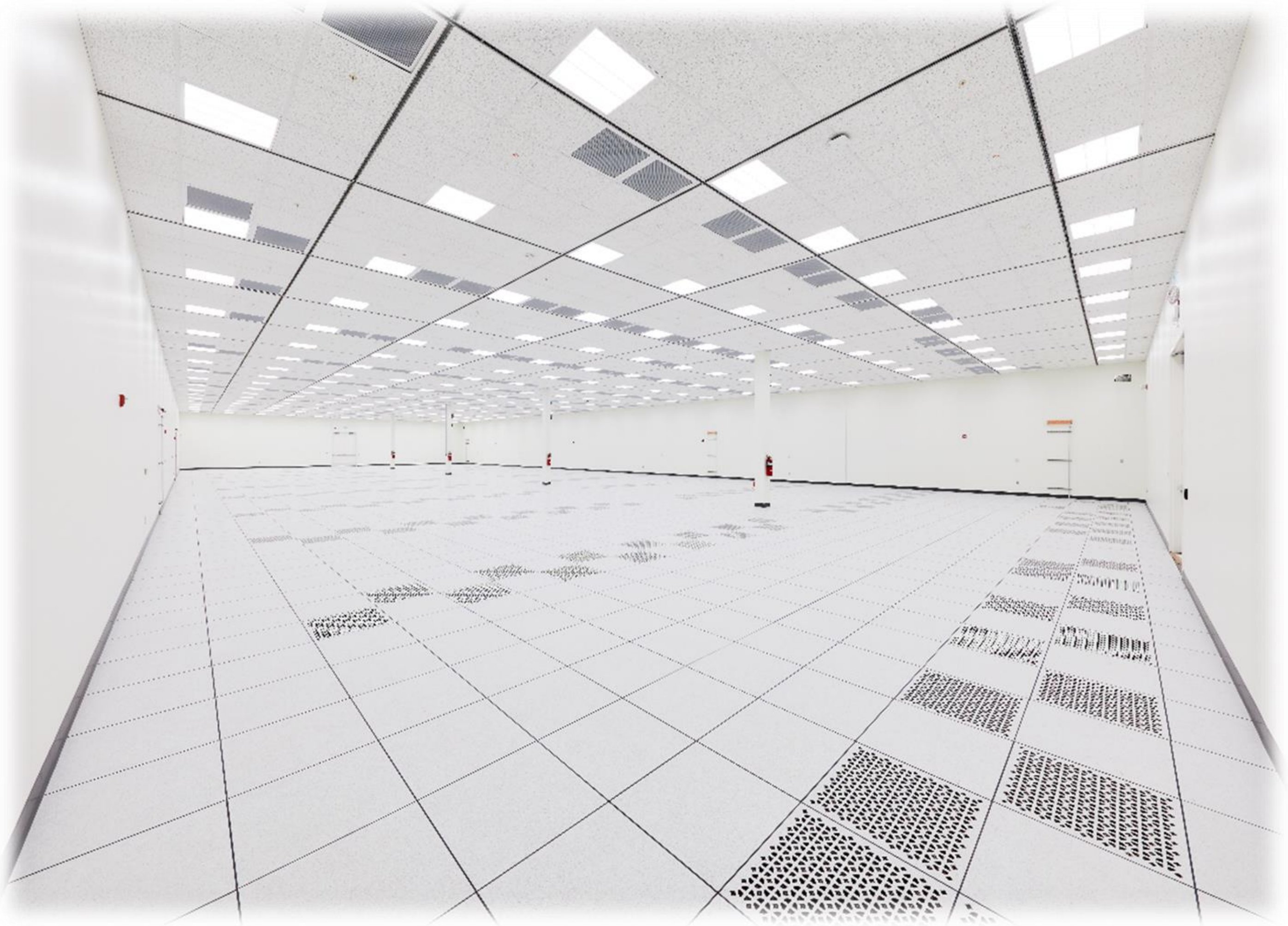


Projects and Advancements

Our Manassas, VA campus which will eventually expand to 4 buildings (2 are currently finished), is in the process of an iterative containment and BMS tuning project that will achieve a target PUE of 1.3 when complete.



Projects and Advancements



Concepts and Future Planning

IMDC are invested and committed to our ISO 50001 program and its continual energy improvement elements. With that, our teams are always researching and exploring new ways to efficiently manage air, and ultimately, energy.

One of the most recent cases of testing new innovation is our evaluation of the new Schneider Electric ExoStruxure Pod at the AZP-2 site.

Green Power and Innovation

IRON MOUNTAIN®

Partner Case Studies

John Sasser

Senior Vice President, Data Center Operations

Sabey Data Centers

Data Sector Meet-Up

Better Buildings Initiative

Monday, June 8th, 2020

SABEY
Data Centers

Sabey Data Centers – Who We Are

Efficiency Design Features

- Latest Uptime Institute Survey – Average industry PUE = 1.67

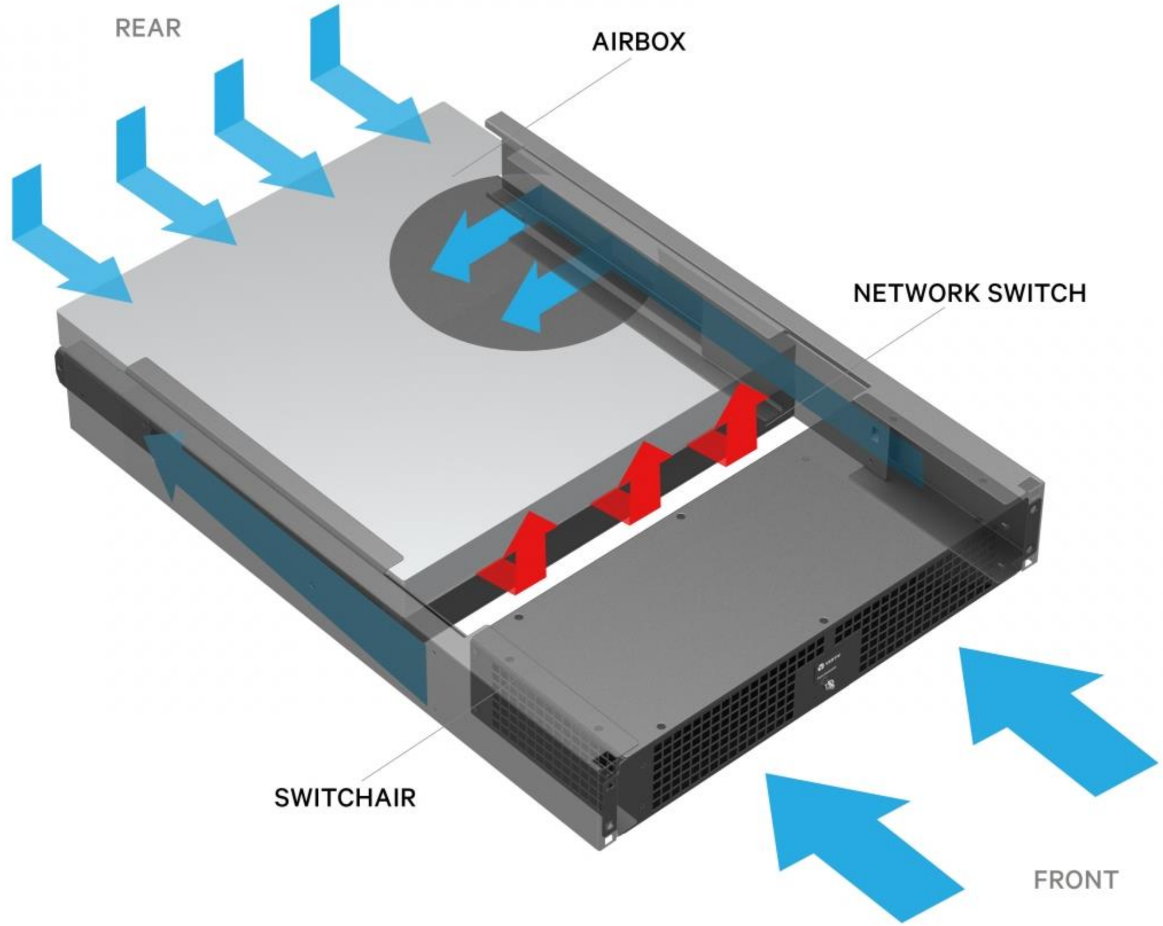
- Sabey:
  - Most efficient data center average annual = 1.13
  - Portfolio weighted average annual = 1.32

- Sabey practices
  - **Hot aisle containment required**
  - Some form of economizer
  - Variable speed fans; fan speed controlled based on differential pressure
  - On slab (no raised floor)
  - High efficiency UPS

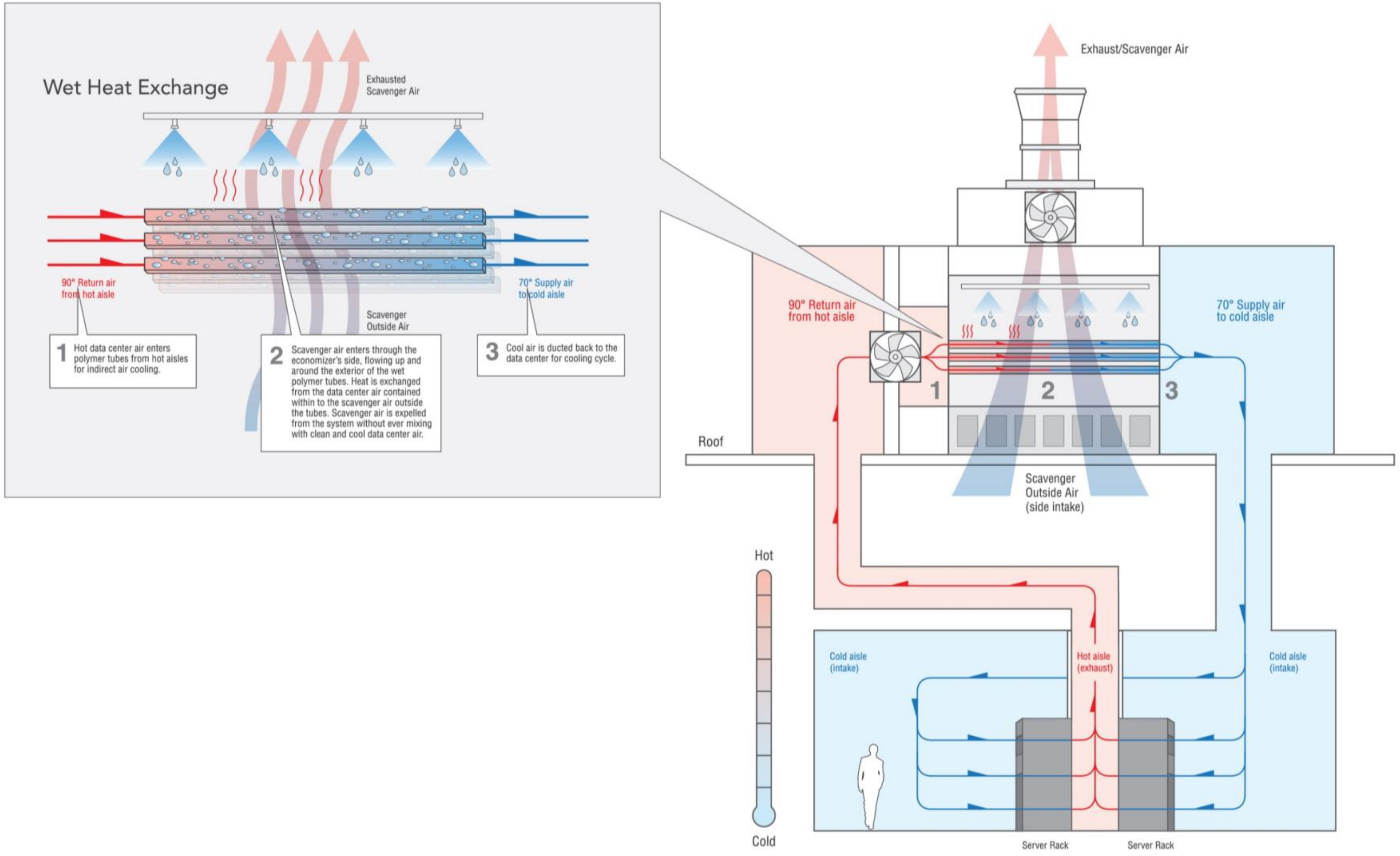
Switch Airflow Management

- Vertiv Geist Switchair – example of a commercially available solution for managing airflow

- Even better – order switches with correct front to back airflow



Indirect Economizer Cooling



Better Building Initiative Benefits

- Networking with very forward-thinking practitioners
- Tours (NREL particularly stands out)
- Green Lease Leaders introduction
- Presentations

Future Efficiency / Sustainability Efforts

- Renewable Energy / Carbon Reduction

- Water Conservation

Questions?

John Sasser

johnsas@sabey.com

SABEY
Data Centers

Partner Case Studies

David Grant

HPC Mechanical Engineer
Oak Ridge National Laboratory

ORNL Data Center Upgrades

David Grant, PE, CEM, DCEP

HPC Mechanical Engineer

Oak Ridge National Laboratory

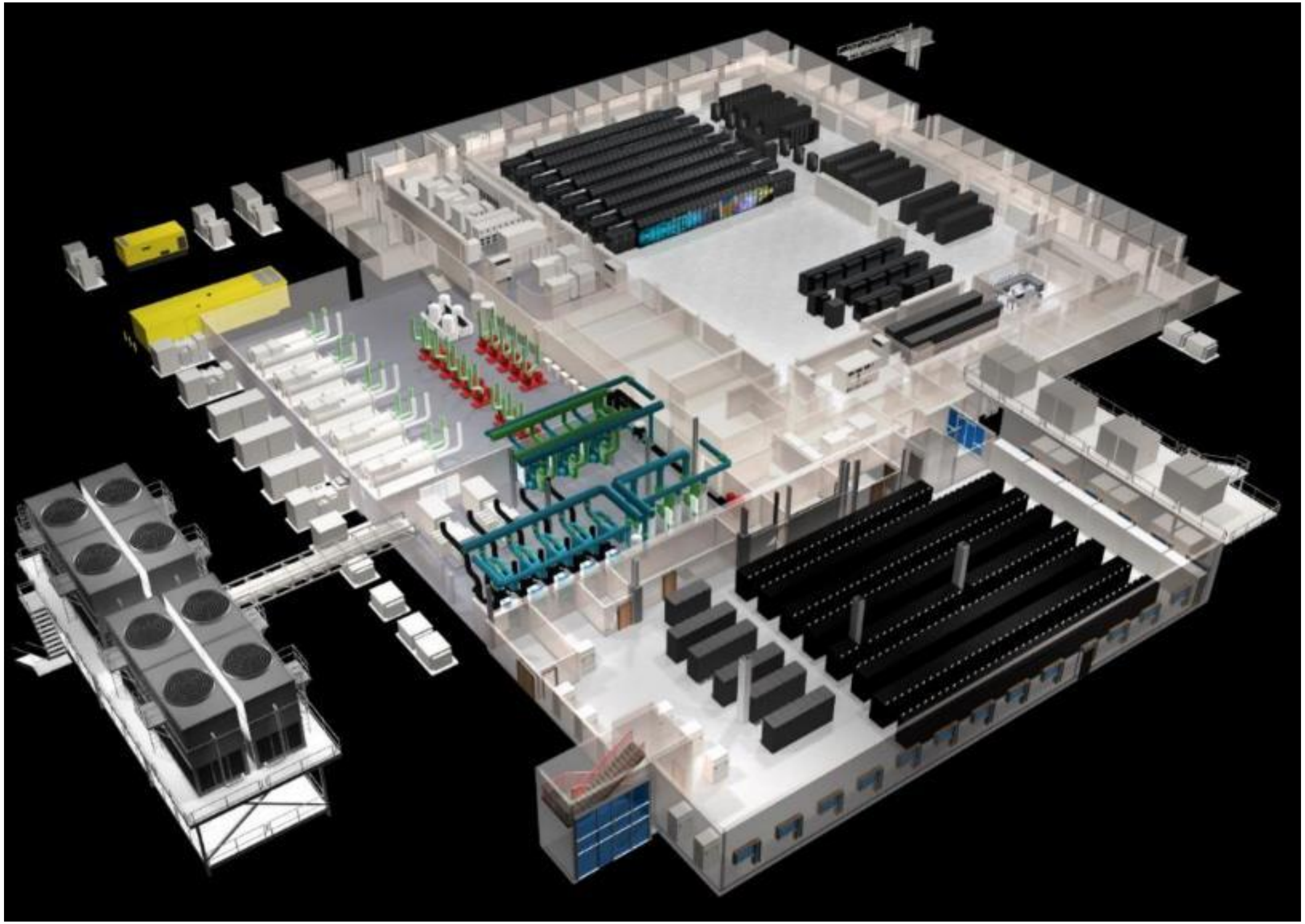
Corresponding Member of ASHRAE TC 9.9

Infrastructure Co-Lead - EEHPCWG

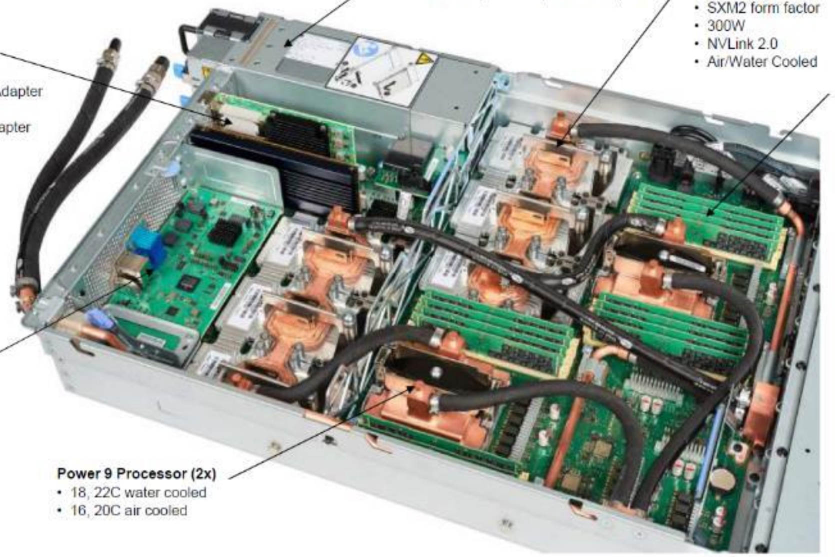
ORNL's Data Center Journey

Today's Overview-

1) Changes during the 5 year period
2) What we gained
3) What we are working on for the future



Summit Node Overview



summit

TOP 500 The List.

NOVEMBER 2019 #1

Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
2,414,592	148,600.0	200,794.9	10,096

JUNE 2019 #1

Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
2,414,592	148,600.0	200,794.9	10,096

NOVEMBER 2018 #1

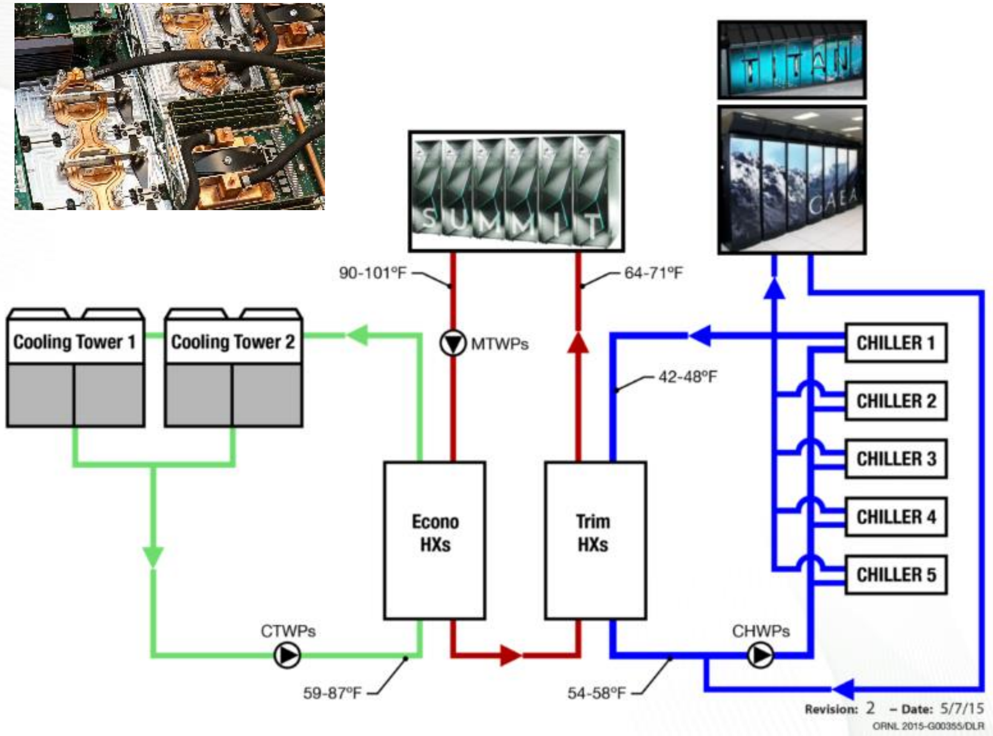
Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
2,397,824	143,500.0	200,794.9	9,783

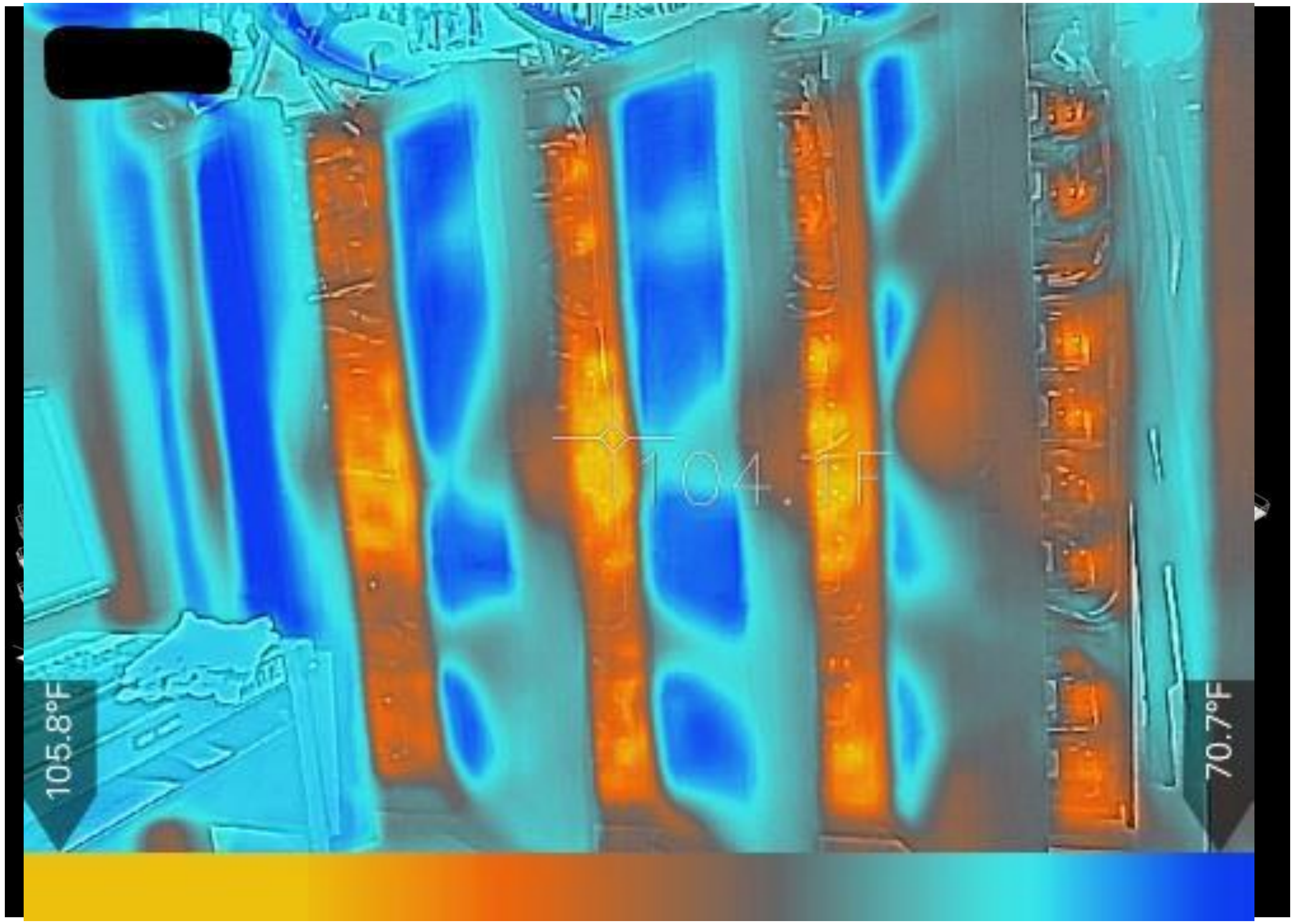
JUNE 2018 #1

Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
2,282,544	122,300.0	187,659.3	8,806

System Description – How do we cool it?

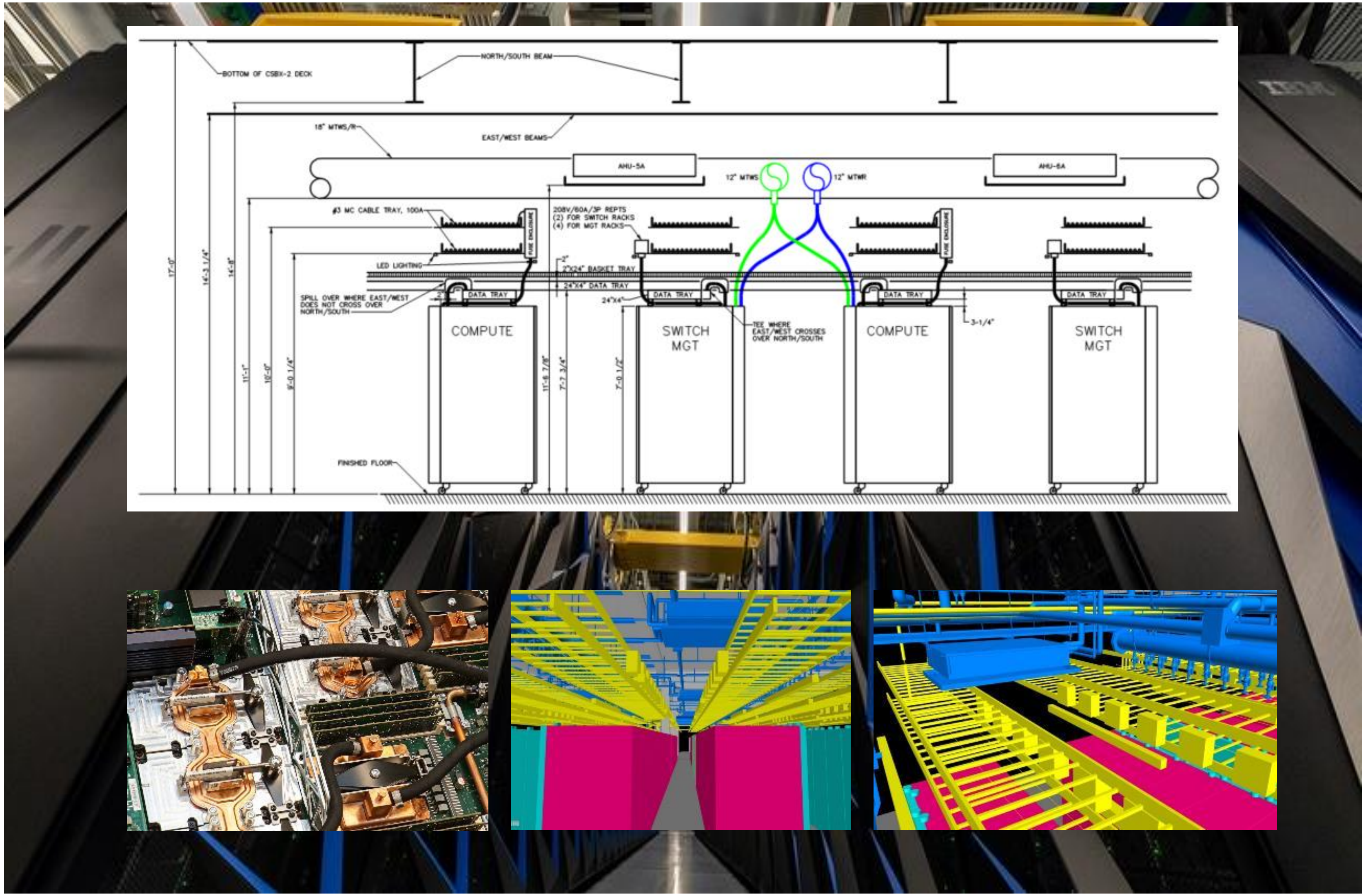
- >100,000 liquid connections



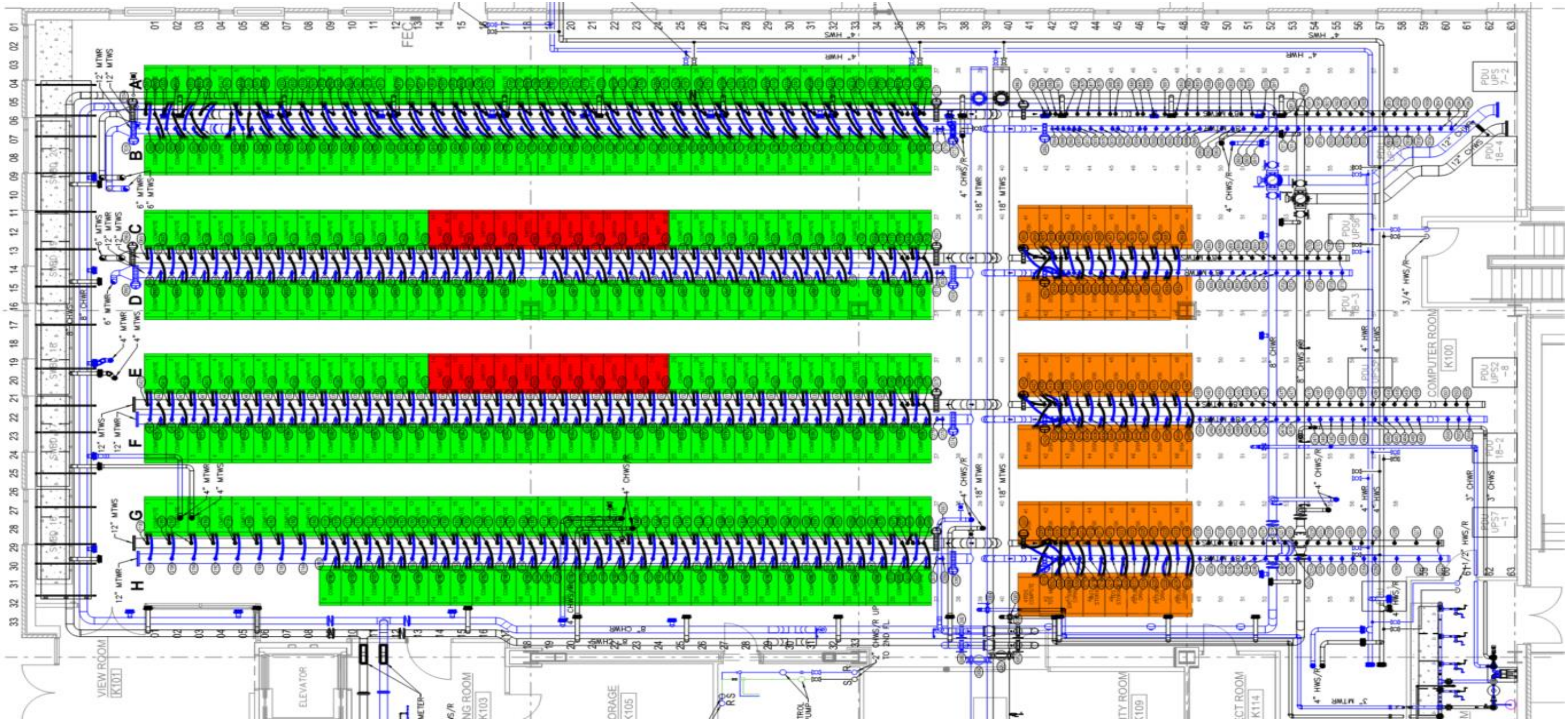


System Description – What's in the data center?

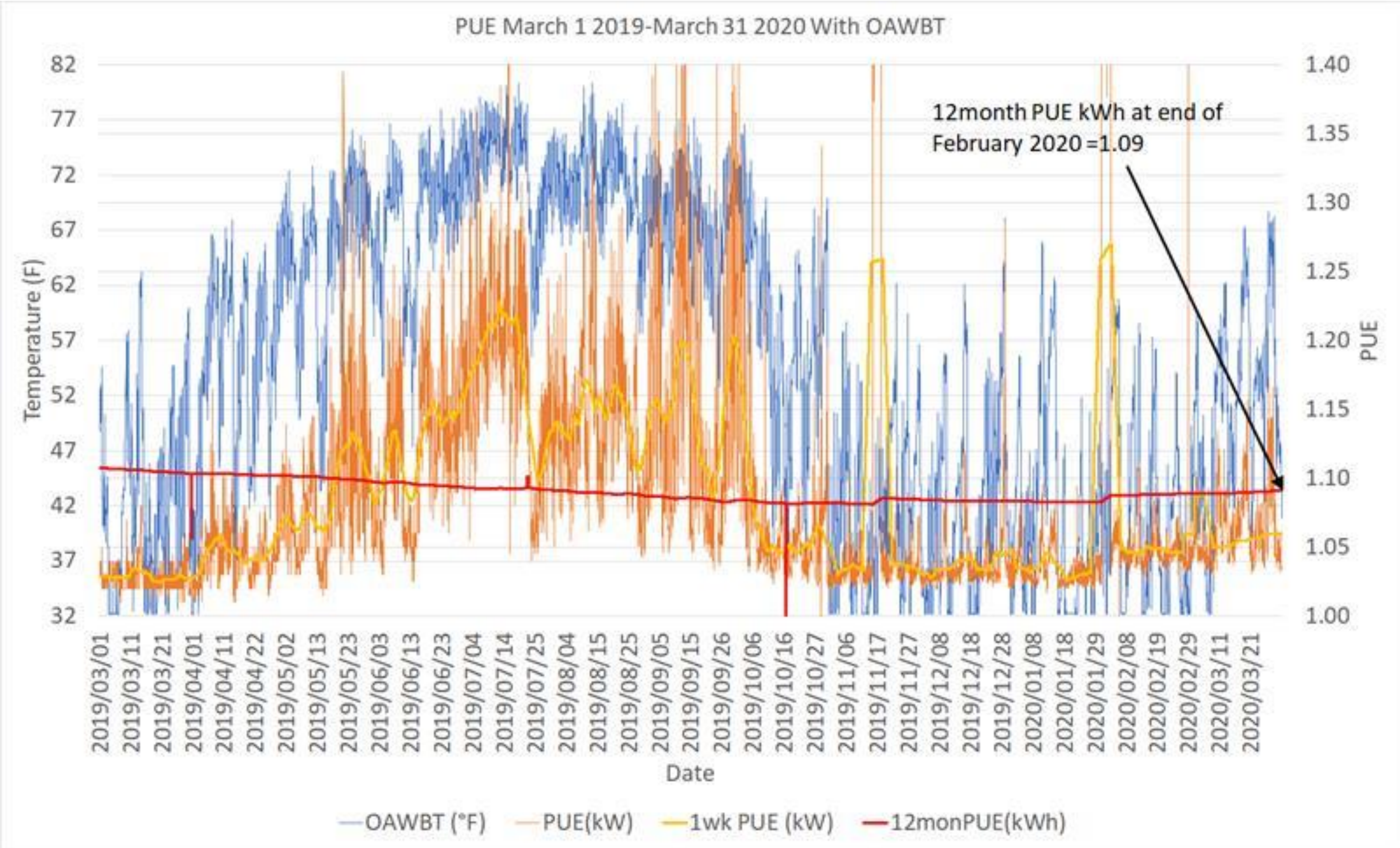
- **Passive RDHXs**- 215,150ft^2 (19,988m^2) of total heat exchange surface (>20X the area of the data center)
  - With a 70°F (21.1 °C) entering water temperature, the room averages ~73°F (22.8°C) with ~3.5MW load and ~75.5°F (23.9°C) with ~10MW load. Note that only ~25% of compute rack load is on the RDHXs.
  - The racks turn over the data center's air volume 2-3 times each minute when under load.
- **CPU cold plates** – 4,105ft^2 (381m^2) of total heat exchange surface
- **GPU cold plates** – 4,448ft^2 (413m^2) of total heat exchange surface
- **Other** - electrical transmission losses, lights, return water piping losses, building envelope, rack radiant, back of rack air exfiltration, VRF AHU fans



System Description – What does the cooling system see in the data center?



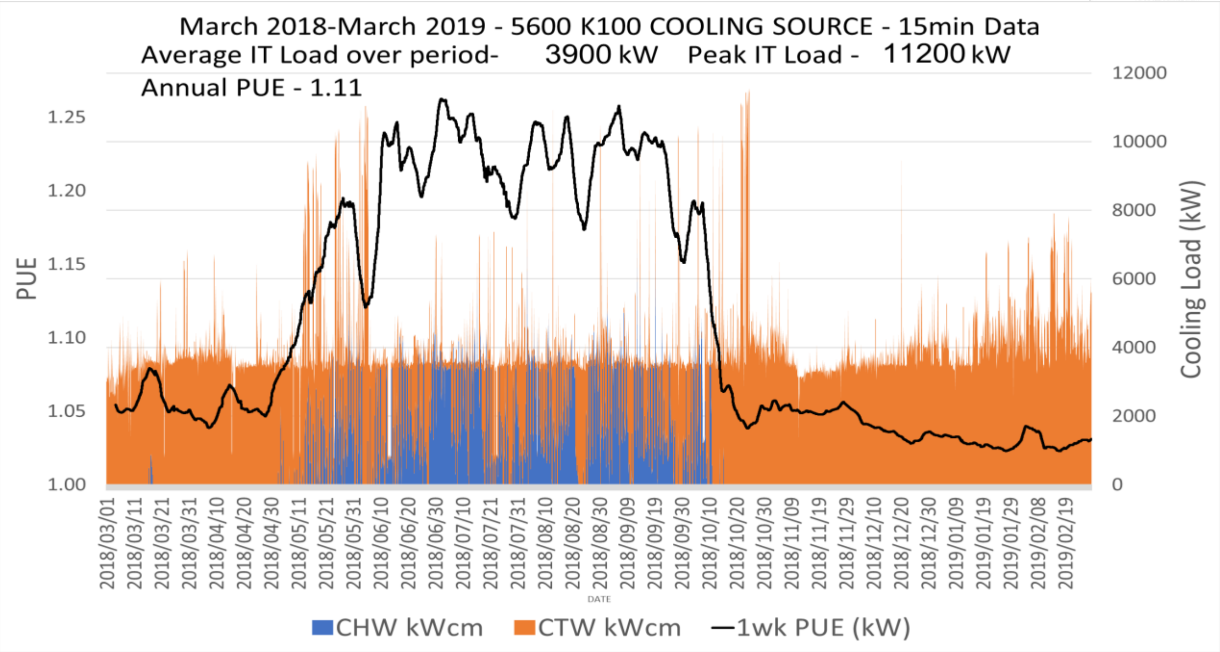
Cooling System Performance - PUE

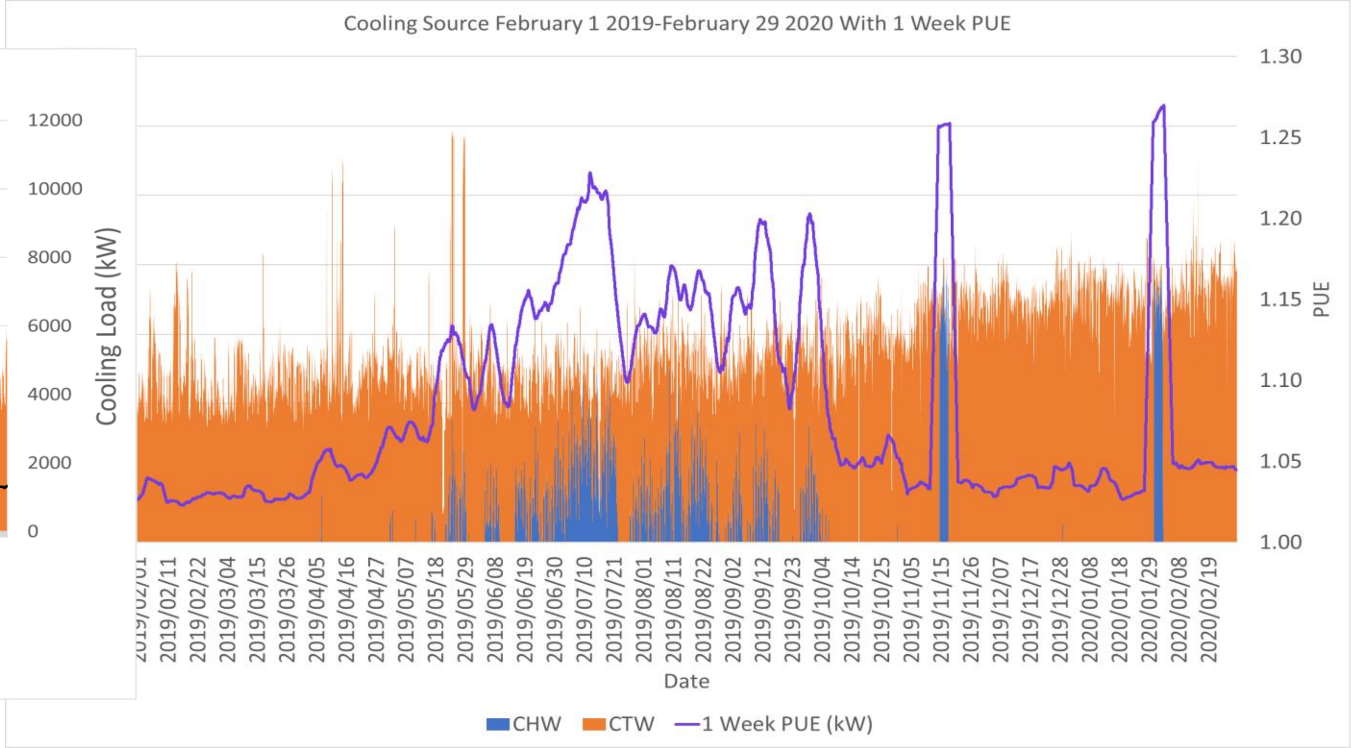


OAK RIDGE National Laboratory

Cooling System Performance – Cooling Source

2019 compared to 2018-
1) Drier Summer
2) More Load
3) Controls Modifications





OAK RIDGE
National Laboratory

Cooling System Performance – Chilled Water Use

Efficiencies

- Chilled Water – ~0.75kW/ton
- Cooling Tower – ~0.25kW/ton

kWh of cooling on an annual basis :

2018-

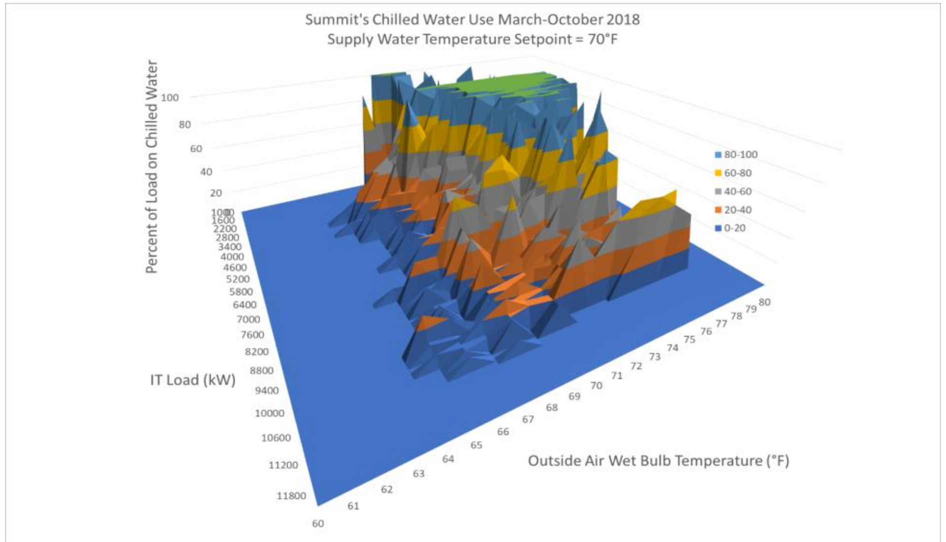
14% Chilled Water

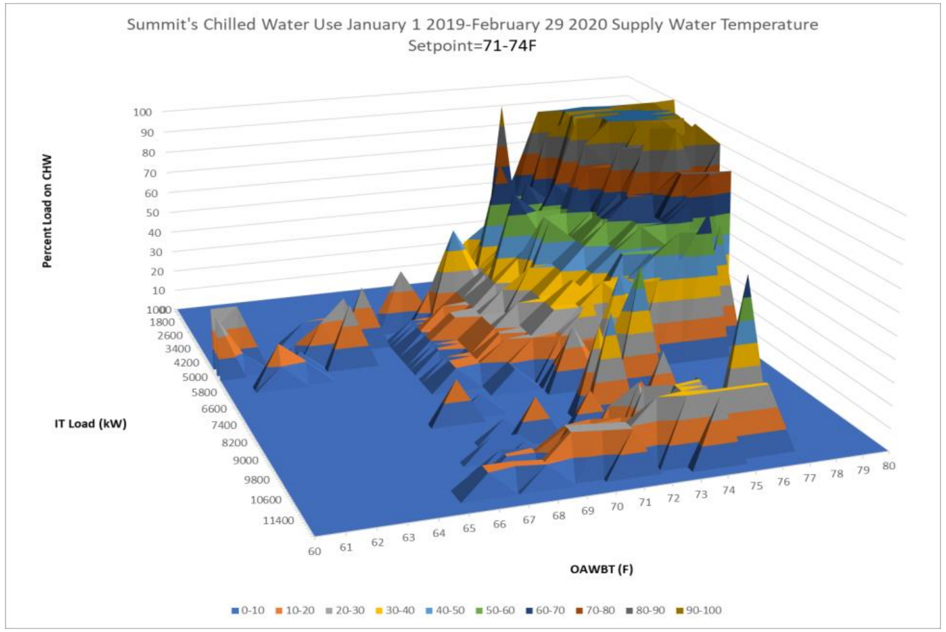
86% Cooling Towers

2019-

9% Chilled Water

91% Cooling Towers





OAK RIDGE National Laboratory

Cooling System Performance – Design Features

Waterside Economizer

Oversized piping

13.8kV brought right to data center

VFDs

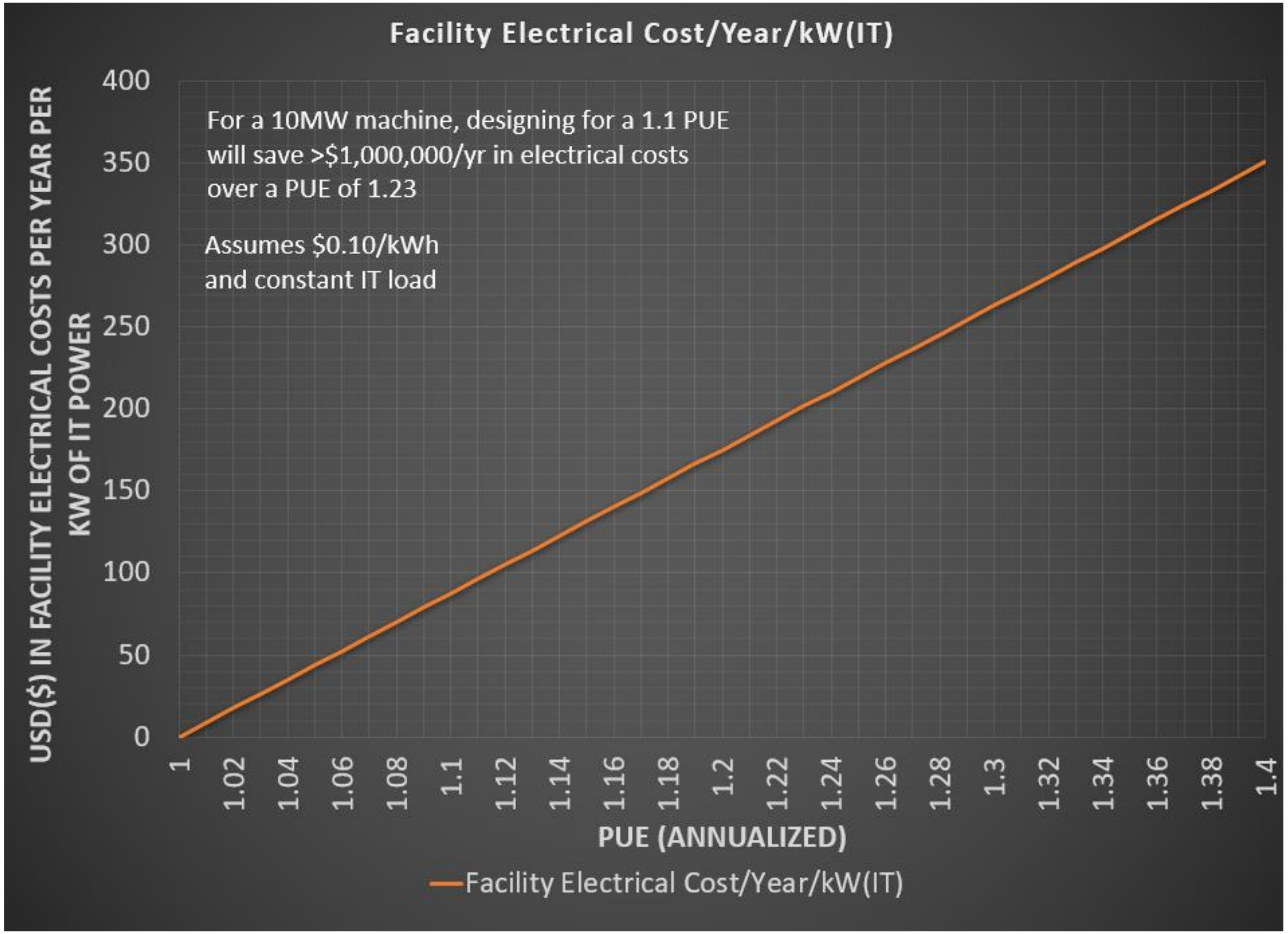
LED lights

3/4 kVA XFMRs are 99.54% @ 50% load and 99.3% @ 100% load

Epoxy coated pumps

Off-line cooling towers use process heat for freeze protection

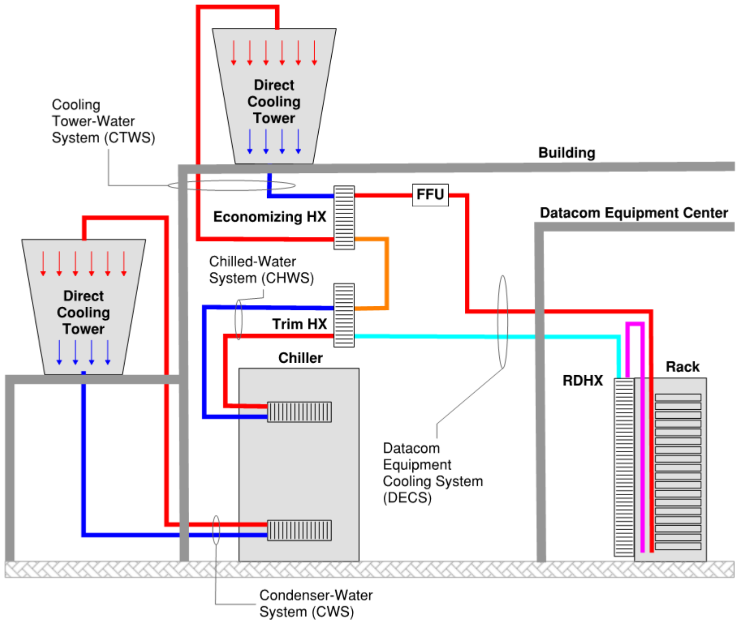
No facility fans for IT loads

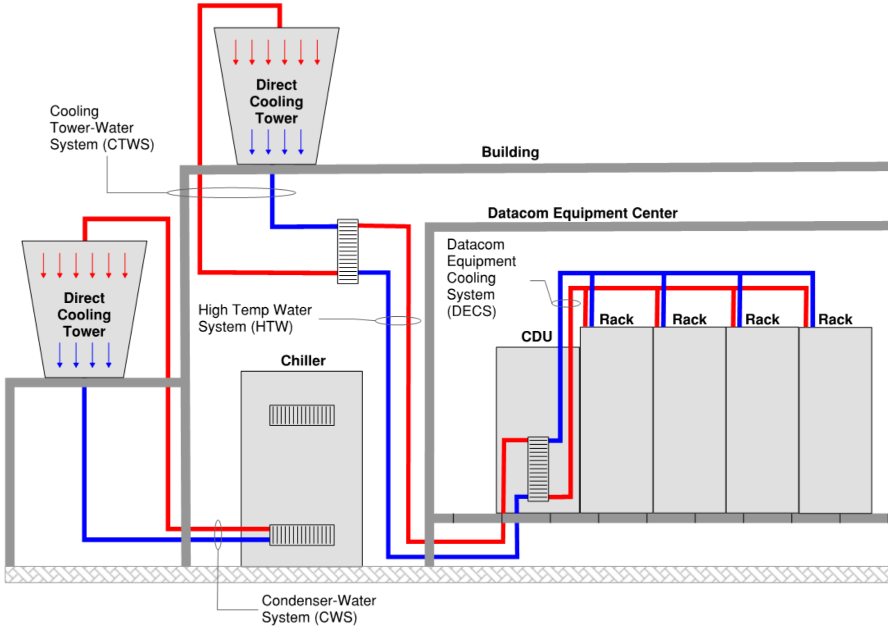


Gains through the Accelerator

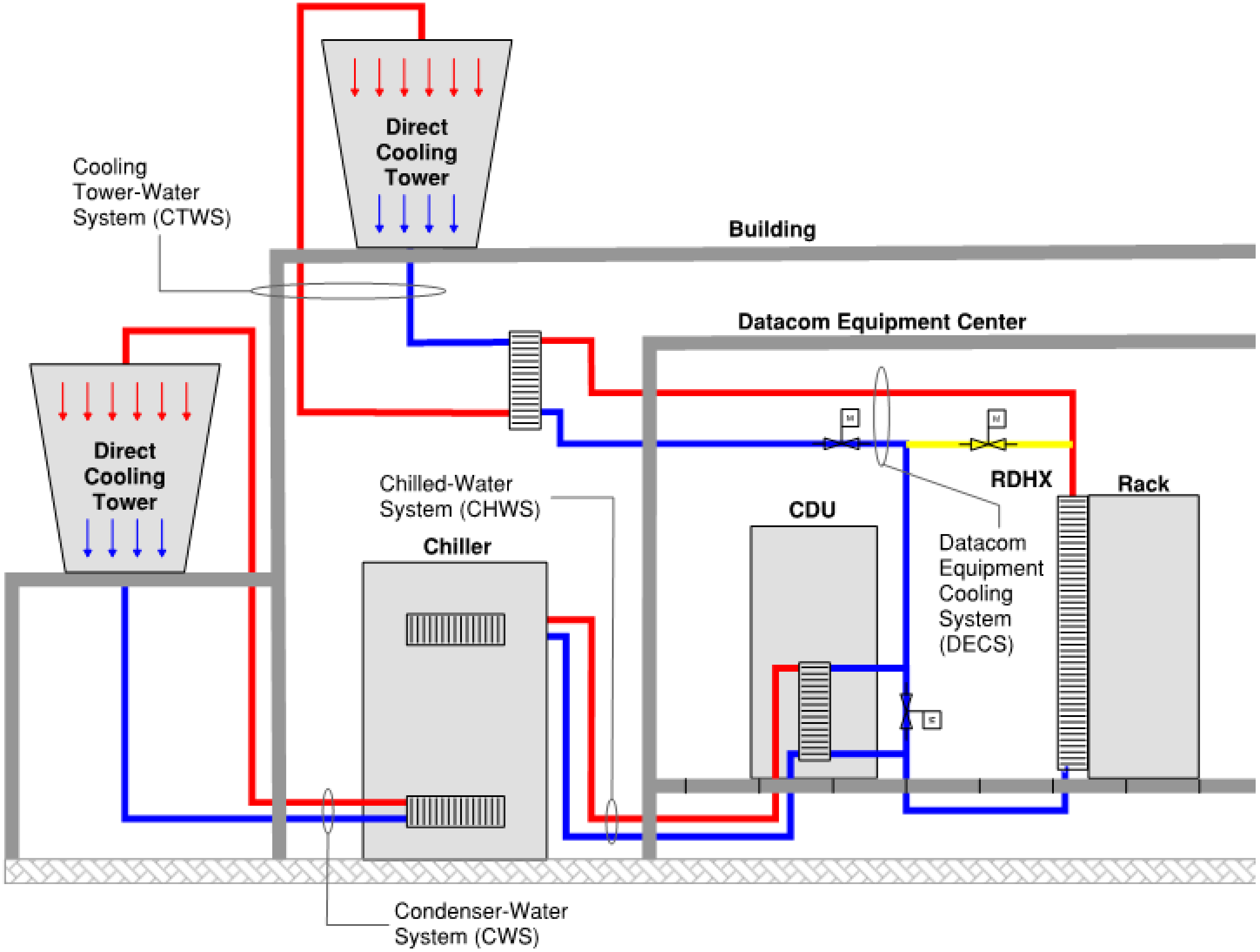
- Extended network and knowledge through the group interactions
- Expertise on metering methodology and control methods
- Revised the way we look at PUE
  - Going from mostly air cooled with chilled water to other hybrid cooling systems
  - PUE at the portfolio level no longer valuable – have to go deeper
    - This requires the right metering
- Gained knowledge on what works and what doesn’t

OLCF-5 – 2021 - Exascale

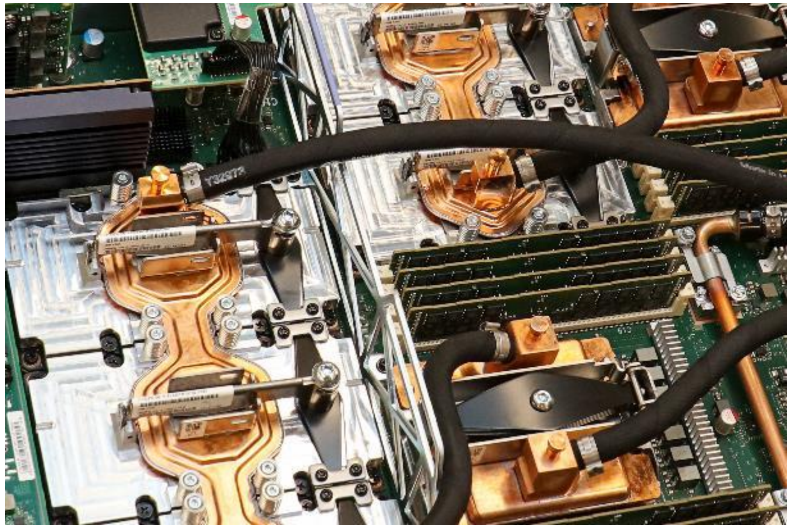




2021 and Beyond – Rack Densities >10kW



Thank You



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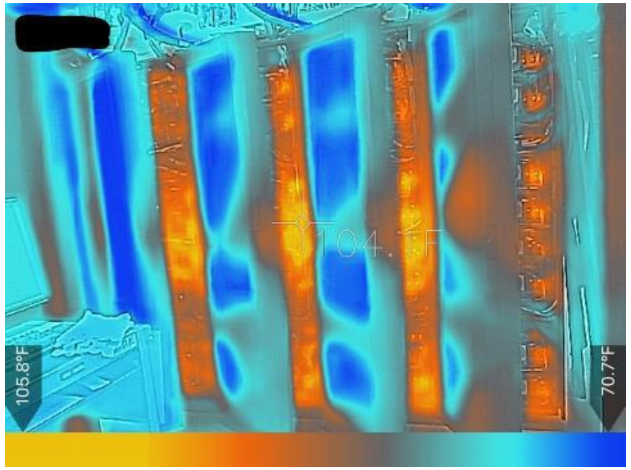


Partner Case Studies

Steve Greenberg

Energy Management Engineer

Lawrence Berkeley National Laboratory

Better Buildings Data Center Accelerator Case Study:
50B Room 1275, Lawrence Berkeley National Laboratory

- Background: the troubled old days
- Intermediate solutions
- The Master Plan: Evolving to Liquid Cooling
- Lessons Learned

LBNL 50B-1275: Background and Evolution

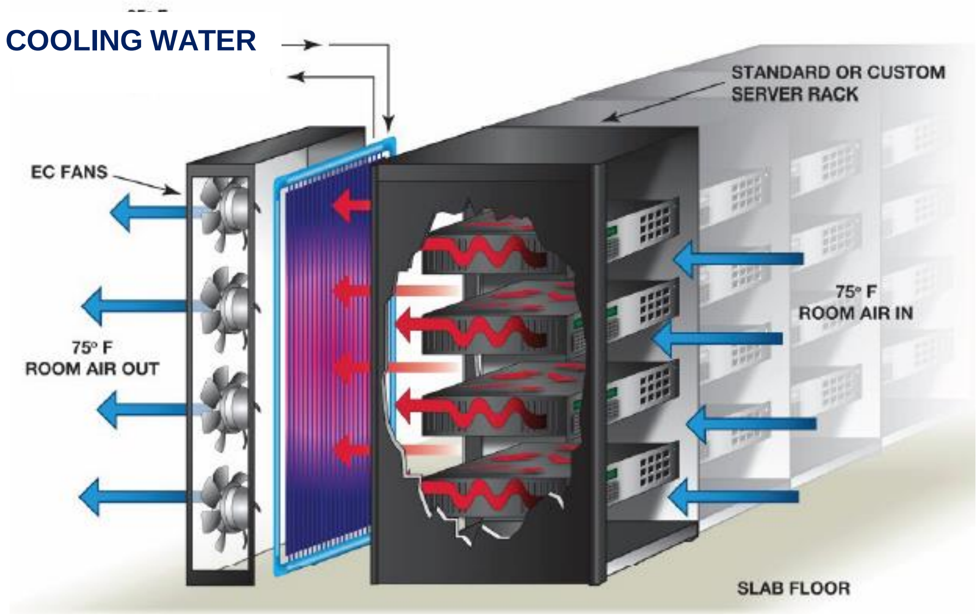
- 1990’s: legacy data center rebuilt to house supercomputer center (NERSC)
- 2000’s: scientific and house computing
- 2010’s to present: high-performance computing owned by research groups
- Water-cooled computer-room air conditioner (CRACs) rejecting to cooling tower
- Even though the CRACs had ample capacity, poor air management meant there were hot spots and the energy efficiency was only fair (PUE over 1.5)

LBNL 50B-1275: Intermediate Solutions, case studies ("The Case Study King")

- Improved air management got cooling under control (2010 report)
- Passive rear doors (Vette)—2010 FEMP case study
  - Some used TRW (closed-loop cooling water)
  - Some used TRW with CHW booster
  - Remaining heat cooled by CRACs
- Additional passive doors with TRW, direct CHW
  - Net cooling
- Additional liquid cooling tests
  - Dual-coil in-rack cooler with TRW, CHW coils (2012 report)
  - Direct-to-chip water cooling (2014 report)
- Several other case studies (monitoring, variable-speed CRAC fans, etc.)

LBNL 50B-1275: The Cooling Master Plan-- Maximize Value of Space and Power

- Move batteries and spinning disks to another space
- Operate 1275 as an ASHRAE A3 area (64-81F per Recommended, but allowable up to 95F IT inlet)
- Active rear doors on TRW only
- Higher cooling water delta T to allow more cooling with the same flow
- Direct-to-chip cooling
- Remove CRACs
- Ultimate build-out at 1.4MW and PUE decreasing from 1.43 (BB baseline) to 1.37 (BB final year) to 1.1 (final configuration)
- 14% reduction in PUE-1 (2019; 325 MWh/yr) with 77% reduction in PUE-1 projected
- New electrical distribution at 240/415V instead of 120/208V



LBNL 50B-1275: Lessons Learned

- Liquid cooling is effective and reliable
- Rear doors are a good bridge technology from air to warm liquid cooling (compressor-free)
- Distribution of heat within passive rear doors is important (Infosys issue)
- Control valves and/or flow balancing pros and cons
- Active rear doors can unload IT fans, making PUE worse but resulting in net energy savings
- Numerous meters needed to track PUE, other performance and to optimize the data center power and cooling

Questions?

Submit Questions

[**www.slido.com**](http://www.slido.com) event code

#BBSummit

Better Buildings Solution Center

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Showcase Projects:

- Large and small buildings
- All sectors
- Specific building types such as schools, hospitals, hotels, grocery stores, universities, civic centers, libraries, offices and labs

Implementation Models (Playbooks):

- Overcome barriers: finance, data, energy management, staff training, community and customer outreach, partnering with utilities, and more
- Multi-faceted and applicable across sectors

Additional Resources, Toolkits, Case Studies

energy.gov/bbsc

Better Buildings: Summer Webinar Series

BEHIND THE METER DISTRIBUTED ENERGY RESOURCES:
BEST PRACTICES FOR INTEGRATING DERS INTO COMMERCIAL BUILDINGS

July 8

PROGRAM DESIGN WITH EVERYONE IN MIND:
LOW-INCOME SOLAR PROGRAM STRATEGIES

July 9

THE DYNAMIC DUO:
UNLEASH PUBLIC SECTOR ENERGY SAVINGS WITH FINANCING AND TECHNICAL ASSISTANCE

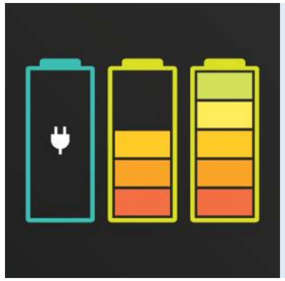
July 14

NEXT-GENERATION BUILDING PERFORMANCE POLICIES:
MAXIMIZING ENERGY SAVINGS AND ENVIRONMENTAL IMPACTS

July 16

STRATEGIES TO COMBINE ENERGY + HEALTH UPGRADES IN MULTIFAMILY HOUSING

July 21



CASE IN POINT:
OREGON'S RECENT EFFORTS TO REDUCE PLUG LOAD ENERGY CONSUMPTION

July 22

EVERYONE HAS A DATA CENTER:
HOW TO BE AN ENERGY CHAMPION FOR YOURS

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August 4

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What is your key takeaway from today's session?

Additional Questions?

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